

(NASA-CR-178920) [DESIGN SUPPORT OF THE
BURST AND TRANSIENT SOURCE EXPERIMENT
(EATSE) OF THE GAMMA RAY OBSERVATORY (GRO)
MISSION] Final Technical Report (California
Univ.) 6 p

N87-10758

Unclas
44244

CSCL 20F G3/74

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Center for Astrophysics
and Space Sciences

FINAL TECHNICAL REPORT
CONTRACT NAS8-35012

PREPARED FOR:

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FROM:

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SEPTEMBER 12, 1986

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1.0 Synopsis

Marshall Space Flight Center (MSFC) awarded the University of California, San Diego (UCSD) NASA contract NAS8-35012 effective November 15, 1982. The contract provided design support of the Burst and Transient Source Experiment (BATSE) of the Gamma Ray Observatory (GRO) mission. The contract as amended, involved engineering design specification and development of the BATSE large area detector and photomultiplier tube assemblies. The contract work directly supported the BATSE Preliminary and Critical Design Reviews. A total of seven modifications served to extend the period of performance and increase the scope until contract expiration, February 28, 1985. Final contract value totalled \$159,110. UCSD became a formal member of the BATSE team as a co-investigating institution under direction of Dr. James L. Matteson as of June 1, 1984 under a new NASA contract NAS8-36081. Subsequent UCSD involvement in BATSE continues under this new contract.

2.0 Background

During 1979, 1980 and early 1981, research and technical staff at UCSD in the Center for Astrophysics and Space Sciences (CASS) were involved in the study phase of the Gamma Ray Spectroscopy Experiment (GRSE) for GRO. UCSD's involvement with GRSE ended at the conclusion of the study phase. The availability of UCSD's technical staff and our continuing interest in the GRO, and the BATSE instrument in particular, prompted submission of UCSD proposal 8638. We proposed to MSFC's Space Science Laboratory for design specification development on BATSE. This proposal was subsequently accepted and resulted in the subject contract.

3.0 Contract History

The original contract Statement of Work specified four tasks:

- 1) A requirements study and preliminary design of the BATSE large area NaI crystal assembly.
- 2) Submission of a material specification and preliminary design drawing of the crystal assembly.
- 3) A preliminary design meeting BATSE requirements for a 5 inch, 9 stage photomultiplier tube assembly (PMT).
- 4) Submission of a material specification and preliminary design drawing for the photomultiplier tube assembly.

All four tasks were completed prior to the BATSE Preliminary Design Review (PDR) on February 22, 1983.

Following contract award on November 15, 1982, design study of Large Area Detector (LAD) mechanical properties began in which six different structural support and fused silica window design concepts were proposed and investigated. By February, 1983 a tentative selection was made which utilized a 3/4 inch thick, 21 inch diameter fused silica window with a 1/2 inch thick, 20 inch diameter NaI crystal. The crystal was retained by adhesive support to the fused silica through the optical coupling. The fused silica was to be supported by a clamp ring and an elastomeric isolator in order to reduce dynamic loads to acceptable levels. A thin aluminum window was to be bonded to the quartz using Hysol EA-934 epoxy to provide a vacuum seal. This design was submitted to MSFC for review and dynamic analysis. This configuration was presented February 22, 1983 at the BATSE Preliminary Design Review.

A preliminary design of a 5" phototube assembly was performed. The design utilized a selected version of an EMI 9791 phototube and incorporated a silicone rubber encapsulated high voltage bias (bleeder) string, high voltage and signal connectors and an aluminum housing.

Modification 1, dated May 15, 1983, provided a one month no cost extension of the period of performance to June 13, 1983.

Modification 2, dated June 3, 1983, provided change of Principal Investigator from E.C. Whipple to J.L. Matteson to provide more direct scientific input for the project scientific requirements.

Modification 3, dated June 15, 1983, provided additions to the scope of work and deliverables, added \$36,816 to the contract value and extended the end date to June 14, 1984. Under this modification, UCSD performed design and specification development and supplied the following deliverables:

- NaI detector (LAD) design/drawing and specification package
- 5 inch, 9 stage PMT design/drawing and specification package
- 5 inch, 11 stage PMT design/drawing and specification package
- 2 inch, PMT design/drawing and specification package
- Molds for 5 inch, 9 stage and 5 inch, 11 stage PMT and 2 inch PMT

Modification 4, dated September 15, 1983, increased the scope of work to include preliminary design of a Gamma Ray Spectroscopy Detector (SD) to be added to the BATSE. Preliminary design drawings, materials lists and preliminary specifications were prepared pursuant to this modification. The specifications included detector envelope, mass, materials mounting method, allowable temperature range, and measurement requirements. Laboratory studies to determine the suitability of the baseline BATSE analog electronics were performed. As a result of this study it was determined that the basic design was acceptable. In the course of this study, fundamental problems with the MQT circuitry were discovered and solutions found which were of important to both the Large Area and Spectroscopy Detectors.

This contract modification also called for evaluation of a suitable 5" photomultiplier tube and associated bleeder string. Data on PMT requirements, power consumption, temperature, and magnetic field shielding were provided. It was determined that the 9 stage BATSE PMT design option previously considered for the LAD would meet the design requirements for the Spectroscopy Detector (SD).

Modification 5, dated February 7, 1984, extended the period of performance through July 31, 1984. This modification expanded the scope of work to continue with detail design and analysis of detector components of BATSE which included the following specific tasks which were accomplished prior to the BATSE Critical Design Review (CDR):

- 1) Detail design of LAD 5" and 2" and SD 5" photomultiplier assemblies. The need for Compton shield layers of copper, tin and lead on the phototube housings was identified and the design changes incorporated.

- 2) Development of detailed mechanical and electrical PMT purchase specifications. These were developed in coordination with MSFC.

- 3) Detail mechanical design of the LAD in coordination with the BATSE structural and dynamic designs and qualified detector crystal manufacturers. This effort lead to a conceptual change in the detector mounting method. Prior to CDR, the elastomeric mount had been envisioned. This configuration had two significant drawbacks. MSFC found adequate modelling of the elastomer proved difficult and there was concern over the light absorbing properties of the elastomer. In addition, GRO dynamic load requirements had recently been revised downward. These factors prompted re-evaluation of the design approach, resulting in adoption of a rigid mounted design. The new design featured EA-934 epoxy mounting of a 20.4 inch diameter fused silica window into an Invar housing. Invar was chosen to minimize thermal stress on the epoxy joint which provided both mechanical retention and vacuum sealing. This design was also submitted to MSFC for dynamic analysis and was found acceptable with the incorporation of some minor enhancements.

- 4) Laboratory characterization and performance testing of the PMT and analog electronics which included stability, high counting rate performance and PMT bleeder string trade off parameters and overall detector resolution. This effort identified the need for zener diode regulation of the last dynode operating voltage and specific tuning of the cathode to first dynode operating voltage for optimum resolution performance.

- 5) Detail design and performance requirement definition on the Spectroscopy detector was as presented at CDR. Details of reflector materials and internal packaging elements were defined.

Modification 6, dated November 26, 1985 provided an increase of \$17,388 to cover cost escalation incurred during preparation for CDR as a result of a

five month disability of the project manager manager and principal development engineer, Mac Chapman. This modification brought the total contract value to the final value of \$159,110.

Modification 7 dated effective August 1, 1984 provided a no-cost extension to the final contract end date of February 28, 1985.

No scientific or technical papers were produced as a result of this contract, however, the results of the technical trade studies, designs and requirements are presented in the BATSE PDR and CDR report documents.